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### **Address of Editorial office:**

Agricultural Science and Technology  
Faculty of Agriculture, Trakia University  
Student's campus, 6000 Stara Zagora  
Bulgaria

Telephone.: +359 42 699330  
+359 42 699446

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## Production properties of flax (*Linum usitatissimum* L.) cultivated in Strumica region, Republic of Macedonia

P. Vuckov\*, M. Ilievski, D. Spasova, L. Mihajlov, N. Markova-Ruzdić

Department for Crop Production, Faculty of Agriculture, University Goce Delchev, 2400 Stip, Republic of Macedonia

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**Abstract.** The purpose of this research was to determine the production properties of 5 flax genotypes cultivated in agro-ecological conditions in the Strumica region, Republic of Macedonia. The research was conducted in a period of two years (2014 and 2015), on the research fields in Strumica at Uni Service - Agro, Faculty of Agriculture, University Goce Delchev, Stip. The research was conducted on 5 genotypes of flax, 4 of which are domestic intermediate genotypes (transitive) flax (Velusina, Duferin, Belan, Belinka) and one French introduced fiber flax variety (Viking). The experiment consisted of five variants in three iterations, divided by the method of random block system for each genotype. The number of fruit per plant in both years of testing is statistically different among different genotypes. In the first year of the examination (2014), the largest number of fruit per plant had genotype Velusina (156) and the lowest (70.3) genotype Belan. In the second year of the examination (2015), the largest number of fruit per plant had the genotype Velusina (102.3) and the lowest (54.7), genotype Belinka. There is no statistically significant difference in number of seeds in the fruit among the tested genotypes. In the first year of the examination (2014), the largest number of seeds in fruit had genotype Velusina (4.63) and the lowest (2.26) - genotype Viking. In the second year of the examination (2015), the largest number of seeds in fruit had genotype Belan (9.96) and the lowest (7.06) - genotype Duferin. In the first year of the examination (2014), the largest number of seed yield per plant in kg/ha had the genotype Viking (500 kg/ha) and the lowest - genotype Belinka (210 kg/ha). In the second year of the examination (2015), the largest number of seed yield per plant in kg/ha had genotype Velusina (1100 kg/ha) and the lowest - genotype Belinka (780 kg/ha). In both years of research (2014 and 2015) there were statistically significant differences on the level of probability of 0.05 and 0.01 among the examined genotypes. Based on the survey results the most promising genotypes in terms of stability, yielding and quality are proposed to producers and industry, both at home and abroad.

**Keywords:** flax, genotypes, fruit, seed, yield

### Introduction

It is known that flax was grown by ancient Egyptians, Greeks and Romans, so, it has been familiar to men for more than 5000 years (Šimetić, 2008). Nowadays this culture is an industrial crop that is grown for fiber, seed and combined fiber and seed (Egumenovski et al., 1988). This culture is very suitable for cultivation, having the following advantages: little need of nitrogen (Hocking et al., 1987), harvesting is done by a combine harvester (Casa et al., 1999), successful growth in temperate climate, resistant to short-term drought (Kocjan, 1999). The products obtained are significant for the textile and oil industry.

The production of flax in the Republic of Macedonia is grown on small areas for its seed (as bird food) and in 2005 – 2006 it was grown on the Faculty of Agricultural Sciences and Food in Skopje as a research project (Dimov, 2006). According to the State Statistical Office, flax areas have not been registered in recent years. Georgievski and Klimov (1991) reported that at first flax was grown on about 50 ha, but since 1960 its areas were reduced to only 1 ha in 1972. In many countries around the world flax is one of the most important crops in healthy human consumption, due to the high content of dietary fiber, omega-3 fatty acids and anticancer lignin (Pospišil et al., 2011). The production of flax is unjustifiably neglected, and in recent years cultivation of flax rapidly rises because of growing demand for flax on domestic and foreign markets (Šimetić, 2008). To meet the market needs for seed flax culture, it is necessary to increase yield (Khourang et al., 2012). Increase of flax yield per unit area (ha) can be achieved through:

productive varieties and better farming practices (Hussein, 2007; Kocjan and Trdan, 2008; Ibrahim, 2009). Transitional flax grows well in warmer and drier areas, with more sunny days. According to Georgievski and Klimov (1991), transitional flax is grown mainly where the average annual rainfall is between 450 and 750 mm.

In recent years interest in oilseed flax has increased as a result of the increased capacity of oil production. Starting from that point, reintroducing flax areas in the Republic of Macedonia imposed the need for an investigation of the characteristics of certain varieties of flax, their acclimatization and production opportunities.

The purpose of this research was to determine the productive characteristics of the five flax genotypes in agro-ecological conditions of the Strumica region, Republic of Macedonia, and based on the results to suggest most promising genotypes in terms of stability, yield and quality to producers and industry, both at home and abroad.

### Material and methods

The research was conducted in field and laboratory conditions. Field examinations were set up at the experimental field in Strumica at UniService-Agro DOOEL, Faculty of Agriculture, University Goce Delchev, Stip, Republic of Macedonia. The research was conducted in the period of two years - 2014 and 2015. As a work material were used five flax genotypes, four of which are domestic intermediate flax genotypes (Velusina, Duferin, Belan, Belinka) and one French introduced fiber flax variety (Viking).

\* e-mail: pavle\_vuckov@hotmail.com

The experiment consisted of five variants in three iterations, divided by the method of random block system with the basic dimension of the parcel of 10 m<sup>2</sup>. The distance between the variants was 50 cm, between iterations 100 cm and between rows 30 cm.

The seeding rate was 50 kg/ha or 50 g per parcel. In the two years of testing, a pre-culture of flax was wheat. Soil was prepared in the same way. Primary tillage was plowing at a depth of 35 cm and the area was fertilized with granulated NPK (15:15:15) fertilizer at an amount of 300 kg/ha and also a pre-sowing tillage was performed with a tiller. Sowing was performed manually in rows at a depth of 2–3 cm.

After sowing and before germination, parcel treatment with herbicide DUAL GOLD 960 EC was performed, against some annual and perennial broadleaf weeds at an amount of 3 l/ha.

During the vegetation, standard farming practices for field production of flax were used. Number of fruit per plant, number of seeds in the fruit, seed yield per plant (g) were monitored. Before the harvest, 10 plants were taken from each repetition, the average is taken from 30 plants (3x10 plants) and total seed yield (kg/ha).

The results were statistically processed by the method analysis of variance, and differences were tested by LSD- test.

## Results and discussion

*Number of fruit per plant.* In both years of testing, the largest number of fruit per plant had genotype *Velusina* (156 in 2014 and 102.3 in 2015), and the lowest - genotypes *Belan* (70.3 in 2014) and *Belinka* (54.7 in 2015), (Table 1). It can be seen that for the two years of investigation differences between genotypes were statistically significant.

The obtained results for the number of fruit per plant are higher than in the studies by Butorac et al. (2003, 2006a, 2006b, 2009, 2010a, 2010b), Andrassy et al. (2004), Pospišil et al. (2004, 2011) and Šurina et al. (2011, 2012). In our case, genotype *Velusina* gave the highest number of fruit per plant and therefore we recommend it to manufacturers in the Republic of Macedonia and other countries with the same agro-ecological conditions.

*Number of seeds in the fruit.* Theoretically it should be 10, however, this is a variety characteristic. That parameter depends on fertilization. In the first year of the examination (2014), the largest number of seeds in fruit had genotype *Velusina* (4.63), and the lowest (2.26) - genotype *Viking*. In the second year (2015) the largest number of seeds in fruit had genotype *Belan* (9.96), and the lowest (7.06) - genotype *Duferin*. The differences between the values of that index among the studied genotypes for both years of testing are not statistically proven.

Some previous investigations (Zedan et al., 1999; Butorac et al., 2010) show that number of seeds in the fruit is higher (5–6 seeds in the fruit) during the first year and lower during the second year, compared to the results of our study. The papers of other authors also show that the number of seeds in the fruit depends on the flax genotype (Zedan et al., 1999; Butorac et al., 2003, 2006a, 2006b, 2009, 2010a, 2010b, 2010; Pospišil et al., 2004; Andrassy et al., 2004 and Šurina et al. 2011, 2012).

*Seed yield per plant.* The yield is a changeable and quite variable characteristic. In both years of research, the highest yield of seed per plant had genotype *Velusina* (5.03 in 2014 and 6.32 in 2015), and the lowest one had genotypes *Belan* (0.7 in 2014) and

*Duferin* (2.78 in 2015). The established values are higher than in the research by Pospišil et al. (2011), (Table 1). The differences in the values among the tested varieties of flax for both years (2014, 2015) are statistically significant.

*Total seed yield per plant (kg/ha).* From the results for total seed yield in kilograms per hectare (Table 1), it can be noted that it ranges from 210 to 1100 kg/ha. In the first year of the examination (2014), the highest total seed yield (kg/ha) had genotype *Viking* (500 kg/ha) and the lowest - genotype *Belinka* (210 kg/ha). In the second year of the examination (2015), the highest total seed yield in kilograms per hectare had genotype *Velusina* (1100 kg/ha) and the lowest - genotype *Belinka* (780 kg/ha). In both years of testing (2014 and 2015) there are statistically significant differences on the level of probability at  $P < 0.05$  and  $P < 0.01$  among the different genotypes.

In studies of other authors, results for increase of total seed yield (kg/ha) between the different genotypes are also represented (Butorac et al., 2003, 2006a, 2006b, 2009, 2010a, 2010b, 2010; Andrassy et al., 2004; Pospišil et al., 2004, 2011; Šurina et al., 2011, 2012; Kopic, 2013).

In our research, yield in 2014 was lower compared to the yield in

**Table 1.** Average values of some production properties of flax in years (n=10)

Variance	Number of fruit per plant	Number of seed in fruit	Seed yield per plant (g)	Total Seed yield per plant (kg/ha)
2014				
Velusina	156	4.63	5.03	380
Duferin	81	3.13	1.16	480
Belan	70.3	2.43	0.7	400
Viking	86.7	2.26	0.8	500
Belinka	90	2.76	1.13	210
LSD 0.05	62.43	n.s	3.54	0.25
0.01	112.17	n.s	6.36	0.46
2015				
Velusina	102.3	7.6	6.32	1100
Duferin	69	7.06	2.78	1010
Belan	68.7	9.96	4.37	950
Viking	76	8.33	3.91	960
Belinka	54.7	8.6	2.98	780
LSD 0.05	41.69	n.s	3.64	0.25
0.01	74.91	n.s	6.55	0.46

2015. The results in the studies of Butorac et al. for two years (2004, 2005) of testing of five varieties of flax by three selection institutions: *Viking* (Cooperative Liniere de Fontaine Cany, France), *Venice* (Agritec, Czech), *Agata*, *Elektra* and *Ilona* (Cebbeco Seeds bv, Netherlands) on two sites (Zagreb and Pasovski coast, Croatian), great variability in yield also was reported between the year of examination. The highest average yield in both years of testing gave varieties *Ilona* 1.4 t/ha (Zagreb region) and *Electra* 1.2 t/ha (Posavski coast region).

Dervišević et al. (2014) started with the cultivation of flax in Bosnia and Herzegovina in order to increase the yield of seed per unit area (ha). The research was conducted on two sites (Gojluk and Ostruznica) in Split region. Three varieties were used (*Mikael*, *Belstar* and x). The highest average yield in both years of examination (2012 – 2013) had the variety *Belstar* 1600 – 1900

kg/ha (sites Gojluk and Ostruznica). According to Pavelek (2001) and Daenekindt (2003) the average yield of flax is between 1.3 and 1.5 t/ha.

The results obtained give reason to propose genotypes *Duferin*, *Viking* and *Belan* for flax seed production in Strumica region. They will be a great importance for the future of agricultural production of this crop.

## Conclusion

Based on two-year investigations of 5 genotypes of flax in the Strumica region, Republic of Macedonia, the following important findings and conclusions can be made: in both years of examination (2014 and 2015) there is no statistically significant difference between genotypes for number of fruit per plant; the largest number of fruit per plant had genotype *Velusina* (156.0 in 2014 and 102.3 in 2015), and the lowest – genotypes *Belan* (70.3 in 2014) and *Belinka* (54.7 in 2015); there is no statistically significant difference in number of seeds in the fruit between the tested genotypes; the number of seeds in the fruit ranges from 5 to 6 seeds; in 2014, the largest number of seeds in fruit had genotype *Velusina* (4.63), and the lowest (2.26) – genotype *Viking*; in 2015, the largest number of seeds in fruit had genotype *Belan* (9.96), and the lowest (7.06) – genotype *Duferin*. The seed yield per plant in both years of testing is with statistically significant differences among the tested varieties. The highest yield of seed per plant had genotype *Velusina* (5.03 in 2014 and 6.32 in 2015), and the lowest yield per plant - genotypes *Belan* (0.7 in 2014) and *Duferin* (2.78 in 2015); in 2014, the highest total seed yield had genotype *Viking* (500 kg/ha), while the lowest - genotype *Belinka* (210 kg/ha); in 2014, the highest total seed yield had genotype *Velusina* (1100 kg/ha), while the lowest - genotype *Belinka* (780 kg/ha); in both years of testing there are statistically significant differences on the level of probability at  $P < 0.05$  and  $P < 0.01$  among the different genotypes. Genotypes *Duferin*, *Viking* and *Belan* are recommended for the production of flaxseed in the Strumica region.

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**Discussion:** The objective of this section is to indicate the scientific significance of the study. By comparing the results and conclusions of other scientists the contribution of the study for expanding or modifying existing knowledge is pointed out clearly and convincingly to the reader.

**Conclusion:** The most important consequences for the science and practice resulting from the conducted research should be summarized in a few sentences. The conclusions shouldn't be numbered and no new paragraphs be used. Contributions are the core of conclusions.

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**Todorov N and Mitev J**, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows. IX<sup>th</sup> International Conference on Production Diseases in Farm Animals, September 11-14, Berlin, Germany.

### Thesis:

**Hristova D**, 2013. Investigation on genetic diversity in local sheep breeds using DNA markers. Thesis for PhD, Trakia University, Stara Zagora, Bulgaria, (Bg).

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### Animal welfare

Studies performed on experimental animals should be carried out according to internationally recognized guidelines for animal welfare. That should be clearly described in the respective section "Material and methods".

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